

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) EP 1 152 120 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.11.2001 Bulletin 2001/45

(51) Int Cl.7: E21B 43/10, E21B 43/08

(21) Application number: 01304042.3

(22) Date of filing: 03.05.2001

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 05.05.2000 US 565899

(71) Applicant: Halliburton Energy Services, Inc.
Dallas, Texas 75381-9052 (US)

(72) Inventors:
• Castano-Mears, Ana M.
Coppell, Texas 75019 (US)
• Gano, John C.
Carrollton, Texas 75007 (US)
• Echols, Ralph H.
Carrollton, Texas 75287 (US)

(74) Representative: Curtis, Philip Anthony et al
A.A. Thornton & Co.,
235 High Holborn
London WC1V 7LE (GB)

(54) Expandable well screen

(57) An expandable well screen (36) provides increased collapse, torsional and tensile strength. In an embodiment, the expandable well screen (36) includes a generally tubular base pipe (38) and an external filter-

ing media (40). The well screen (36) is configured to have sufficient torsional and tensile strength for conveyance and positioning in a wellbore, while also having sufficient strength to prevent collapse when the screen (38) is radially expanded.

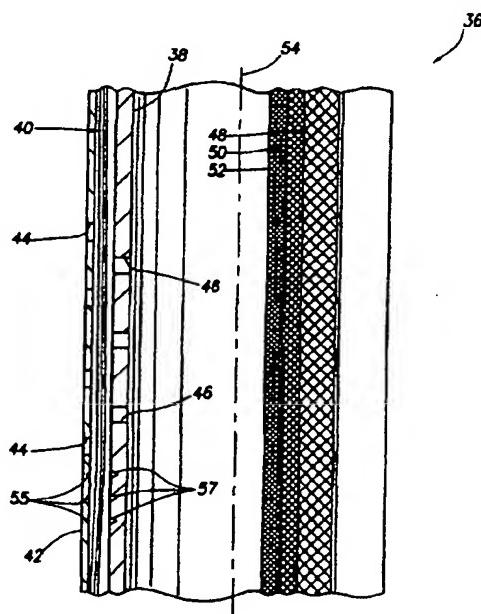


FIG.2

EP 1 152 120 A2

Description

[0001] The present invention relates generally to operations performed, and equipment utilized, in conjunction with a subterranean well, and more particularly relates to provides an expandable well screen.

[0002] It is useful in some circumstances to be able to convey generally tubular equipment into a subterranean well, position the equipment within a wellbore of the well, and then outwardly expand the equipment in the wellbore. For example, a restriction in the wellbore may prevent the equipment in its expanded configuration from passing through that part of the wellbore, but the equipment may pass through the restriction in its retracted configuration. In one application of this principle, it is known to use expandable well screens in wellbores.

[0003] An example of the potential usefulness of expandable equipment in a wellbore is where the wellbore intersects a productive, relatively unconsolidated, formation. It would be desirable in many situations to be able to utilize a well screen to filter production from the formation, while foregoing the expense of cementing casing in the wellbore and performing a gravel packing operation. Unfortunately, without any radial support the unconsolidated formation would likely collapse into the wellbore, causing additional expense and loss of revenue. Conventional non-expandable well screens must necessarily be smaller than the wellbore in order to be conveyed therethrough, and so they are incapable of providing any radial support for an unconsolidated formation. Conventional expandable well screens are not designed for contacting and providing radial support for a formation, and so are unsuited for this purpose.

[0004] Therefore, it can be seen that it would be quite desirable to provide an expandable well screen which may be used for contacting and providing radial support for a formation intersected by a wellbore. It would also be desirable to provide an expandable well screen having enhanced torsional and tensile strength. It is accordingly an object of the present invention to provide such an expandable well screen.

[0005] In carrying out the principles of the present invention, in accordance with an embodiment thereof, an expandable well screen is provided. When radially extended downhole, the well screen may be used to support an unconsolidated formation. Of course, the well screen may also be used in situations in which a formation is not supported by the screen. Additionally, an expandable well screen having enhanced torsional and tensile strength is provided.

[0006] According to one aspect of the invention there is provided an expandable well screen, comprising: a filtering media, the filtering media stretching circumferentially when the well screen is radially outwardly expanded.

[0007] In an embodiment, the filtering media comprises an elongated strip disposed in a helical configuration.

[0008] In an embodiment, the filtering media includes

a layer of relatively fine filtering material sandwiched between layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material.

5 [0009] In an embodiment, the filtering media is generally tubular and has multiple slots formed therethrough. The slots are arranged helically relative to a longitudinal axis of the filtering media.

10 [0010] In an embodiment, the filtering media filters particles have a size of greater than 500 μm when the well screen is radially outwardly expanded.

15 [0011] In an embodiment, openings through the filtering media for fluid flow therethrough change size by less than fifty percent when the well screen is radially outwardly expanded.

[0012] According to another aspect of the invention there is provided an expandable well screen includes a generally tubular base pipe with a series of rows of holes formed through a sidewall of the base pipe, and a filtering media disposed externally on the base pipe. The holes of each row interconnect with each other, forming a larger opening, when the base pipe is expanded radially outward.

20 [0013] In an embodiment, the series of rows of holes is arranged helically on the base pipe relative to the longitudinal axis.

[0014] In an embodiment, wherein the holes in each row are distributed along a line.

25 [0015] In an embodiment, the expandable well screen further comprises a generally tubular protective shroud outwardly overlying the filtering media. The shroud preferably includes a recess formed internally thereon, the recess permitting transverse fluid flow between the shroud and the filtering media when the filtering media is compressed against the shroud.

30 [0016] In an embodiment, the filtering media includes a layer of relatively fine filtering material sandwiched between layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material.

35 [0017] In an embodiment, the filtering media includes a woven material having strands thereof which are arranged helically relative to the base pipe longitudinal axis.

40 [0018] In an embodiment, the base pipe includes a recess externally formed thereon, the recess permitting transverse fluid flow between the base pipe and the filtering media when the filtering media is compressed against the base pipe.

45 [0019] According to another aspect of the invention there is provided an expandable well screen is provided which includes a generally tubular base pipe with a series of holes formed through a sidewall of the base pipe, and a filtering media disposed externally on the base pipe. The holes are distributed helically relative to a longitudinal axis of the base pipe. When the base pipe is expanded radially outward, each of the holes is compressed in the direction of the base pipe longitudinal ax-

is.

[0020] In an embodiment, the expandable further comprises a generally tubular protective shroud outwardly overlying the filtering media.

[0021] In an embodiment, the filtering media includes a layer of relatively fine filtering material sandwiched between layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material.

[0022] In an embodiment, the filtering media includes a woven material having strands thereof which are arranged helically relative to the base pipe longitudinal axis.

[0023] According to another aspect of the invention there is provided an expandable well screen, comprising: an elongated strip of filtering media wrapped helically about a longitudinal axis. The filtering media may be wrapped helically about a base pipe. The filtering media may be wrapped in multiple wraps about the base pipe, preferably with a connection formed between adjacent wraps. The connection may be a welded seam between the wraps, or it may include a connector between the wraps. If a connector is used, various types of lines (electric, hydraulic, communication, chemical injection, etc.) may be positioned adjacent the connector.

[0024] In an embodiment, the filtering media includes a woven material with strands thereof oriented helically relative to the longitudinal axis.

[0025] In an embodiment, the filtering media includes a layer of relatively fine filtering material sandwiched between layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material.

[0026] According to another aspect of the invention there is provided an expandable well screen, comprising: multiple elongated strips of filtering media spaced apart and distributed circumferentially about a longitudinal axis and extending parallel to the longitudinal axis; and multiple elongated expansion strips, one of the expansion strips being interconnected between each adjacent pair of the filtering media strips, and the expansion strips lengthening circumferentially to thereby increase circumferential separation between the filtering media strips. The filtering media and expansion strips may be circumferentially distributed about a base pipe. The filtering media strips and expansion strips are arranged in an alternating fashion. The filtering media strips and expansion strips are connected to each other so that, when the base pipe is expanded radially outward, the expansion strips lengthen circumferentially, thereby increasing the circumferential separation between the filtering media strips.

[0027] In an embodiment, the expansion strips have longitudinal corrugations formed thereon, and wherein the corrugations are at least partially straightened when the expansion strips lengthen circumferentially.

[0028] In an embodiment, the filtering media includes a layer of relatively fine filtering material sandwiched be-

tween layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material.

[0029] In an embodiment, the expandable well screen further comprises multiple elongated protective shroud strips, one of the shroud strips outwardly overlying each of the filtering media strips. Each of the shroud strips may be interconnected between two of the expansion strips.

[0030] In an embodiment, the expandable well screen further comprises at least one retaining member securing at least one of the expansion strips in a compressed configuration thereof, the retaining member releasing the at least one expansion strip for expansion thereof when the expansion strips lengthen circumferentially.

[0031] In an embodiment, the expandable well screen further comprises multiple elongated protective shroud strips, one of the shroud strips outwardly overlying each of the filtering media strips, and the retaining member being connected to two of the shroud strips.

[0032] In an embodiment, the retaining member is connected across at least one of the expansion strips.

[0033] In an embodiment, the retaining member is attached directly to the at least one expansion strip.

[0034] In an embodiment, wherein the retaining member extends externally across a longitudinally extending fold formed in a base pipe.

[0035] In an embodiment, the retaining member extends externally across a longitudinally extending undulation in a base pipe.

[0036] In an embodiment, the base pipe is deformed to a radially reduced configuration thereof.

[0037] In an embodiment, the base pipe has an hour-glass cross-sectional shape.

[0038] According to another aspect of the invention there is provided an expandable well screen, comprising: a generally tubular filtering media, the filtering media including expansion portions thereof permitting circumferential lengthening of the filtering media.

[0039] The generally tubular filtering media may outwardly overlie a base pipe. The expansion portions may be longitudinally extending corrugations formed on the filtering media. The screen may include longitudinally extending ribs positioned between the base pipe and the filtering media, and at least one of the ribs may be positioned between the base pipe and one of the expansion portions. One or more of the ribs may be substantially hollow and may have various lines (electrical, hydraulic, communication, chemical injection, etc.) extending therethrough. The filtering media may include a series of circumferentially extending and preferably helically arranged slots, desirably with a width of each slot decreasing when the base pipe is expanded radially outward.

[0040] According to another aspect of the invention there is provided an expandable well screen, comprising: a filtering media; a series of (preferably longitudinally) extending and circumferentially distributed ribs

disposed externally relative to the filtering media; and a generally tubular protective shroud outwardly overlying the ribs.

[0041] The filtering media may overlie a generally tubular base pipe. An expansion strip may be connected to opposite circumferential ends of the filtering media, with the expansion strip elongating circumferentially when the base pipe is radially outwardly expanded, or the filtering media may have longitudinal corrugations formed thereon which at least partially straighten when the base pipe is radially outwardly expanded. The expansion strip may include longitudinal corrugations formed thereon.

[0042] In an embodiment, the filtering media includes a woven sintered filtering material.

[0043] In an embodiment, the filtering media includes at least two layers of the woven sintered filtering material.

[0044] The filtering media in the above expandable well screens may include a layer of relatively fine filtering material sandwiched between layers of relatively coarse filtering material. The relatively fine filtering material may be a sintered woven filtering material. If the filtering media includes a woven material, the material may have strands thereof which are arranged helically relative to the base pipe longitudinal axis.

[0045] Reference is now made to the accompanying drawings in which:

FIGS. 1A & 1B are schematic views of an embodiment of a method according to the present invention;

FIG. 2 is an enlarged scale partially cross-sectional and partially elevational view of a first embodiment of an expandable well screen according to the present invention;

FIGS. 3A & 3B are elevational views of an embodiment of a base pipe of the first well screen;

FIGS. 4A & 4B are elevational views of an alternative embodiment of the base pipe of the first well screen;

FIG. 5 is an elevational view of a second embodiment of an expandable well screen according to the present invention;

FIG. 6 is an enlarged scale view of a portion of the second well screen;

FIG. 7 is an enlarged scale view of an alternative configuration of the portion of the second well screen;

FIGS. 8A & 8B are cross-sectional views of a third embodiment of an expandable well screen according to the present invention;

FIGS. 9A & 9B are cross-sectional views of a fourth embodiment of an expandable well screen according to the present invention;

FIGS. 10A & 10B are cross-sectional views of fifth a embodiment of an expandable well screen according to the present invention;

FIG. 11 is an elevational view of a sixth a embodiment of an expandable well screen according to the present invention;

FIG. 12 is a cross-sectional view of the sixth embodiment of the expandable well screen, taken along line 12-12 of FIG. 11;

FIG. 13 is a cross-sectional view of a seventh a embodiment of an expandable well screen according to the present invention;

FIG. 14 is a cross-sectional view of an eighth a embodiment of an expandable well screen according to the present invention;

FIG. 15 is an elevational view of a ninth a embodiment of an expandable well screen according to the present invention;

FIG. 16 is a cross-sectional view of the ninth embodiment of the well screen, taken along line 16-16 of FIG. 15;

FIG. 17 is an enlarged scale cross-sectional view of the ninth embodiment of the well screen, taken along line 17-17 of FIG. 15; and

FIG. 18 is an enlarged scale view of a portion of the ninth embodiment of the well screen.

25 [0046] Representatively illustrated in FIGS. 1A & B is a method 10 which embodies principles of the present invention. In the following description of the method 10 and other apparatus and methods described herein, directional terms, such as "above", "below", "upper", "lower", etc., are used only for convenience in referring to the accompanying drawings. Additionally, it is to be understood that the various embodiments of the present invention described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of the present invention.

[0047] Referring initially to FIG. 1A, in the method 10, a screen assembly 12 including multiple expandable well screens 14, 16, 18 is conveyed into a wellbore 20.

30 The wellbore 20 intersects multiple formations or zones 22, 24, 26 from which it is desired to produce fluids. The screens 14, 16, 18 are positioned opposite respective ones of the zones 22, 24, 26.

[0048] The wellbore 20 is depicted in FIGS. 1A & B as being uncased, but it is to be clearly understood that the principles of the present invention may also be practiced in cased wellbores. Additionally, the screen assembly 12 is depicted as including three individual screens 14, 16, 18, with only one of the screens being positioned opposite each of the zones 22, 24, 26, but it is to be clearly understood that any number of screens may be used in the assembly, and any number of the screens may be positioned opposite any of the zones, without departing from the principles of the present invention. Thus, each of the screens 14, 16, 18 described herein and depicted in FIGS. 1A & B may represent multiple screens.

[0049] Sealing devices 28, 30, 32, 34 are intercon-

nected in the screen assembly 12 between, and above and below, the screens 14, 16, 18. The sealing devices 28, 30, 32, 34 could be packers, in which case the packers would be set in the wellbore 20 to isolate the zones 22, 24, 26 from each other in the wellbore. However, the sealing devices 28, 30, 32, 34 are preferably expandable sealing devices, which are expanded into sealing contact with the wellbore 20 when the screen assembly 12 is expanded as described in further detail below. For example, the sealing devices 28, 30, 32, 34 may include a sealing material, such as an elastomer, a resilient material, a non-elastomer, etc., externally applied to the screen assembly 12.

[0050] Referring additionally now to FIG. 1B, the screen assembly 12 has been expanded radially outward. The sealing devices 28, 30, 32 and 34 now sealingly engage the wellbore 20 between the screens 14, 16, 18, and above and below the screens.

[0051] Additionally, the screens 14, 16, 18 preferably contact the wellbore 20 at the zones 22, 24, 26. Such contact between the screens 14, 16, 18 and the wellbore 20 may aid in preventing formation sand from being produced, preventing the formations or zones 22, 24, 26 from collapsing into the wellbore, etc. However, this contact is not necessary in keeping with the principles of the present invention.

[0052] The use of an expandable screen assembly 12 has several additional benefits. For example, the radially reduced configuration shown in FIG. 1A may be advantageous for passing through a restriction uphole, and the radially expanded configuration shown in FIG. 1B may be advantageous for providing a large flow area and enhanced access therethrough. However, the expandable screen assembly 12 must have sufficient torsional and tensile strength so that it is not damaged while being conveyed and positioned in the wellbore 20 and, if the screens 14, 16, 18 are to be expanded into contact with the zones 22, 24, 26 for radial support thereof, the screens must have sufficient collapse resistance.

[0053] Referring additionally now to FIG. 2, an expandable well screen 36 embodying principles of the present invention is representatively illustrated. The well screen 36 may be used for one or more of the well screens 14, 16, 18 in the method 10. However, it is to be clearly understood that the well screen 36 may be utilized in any other method without departing from the principles of the present invention.

[0054] The well screen 36 includes a generally tubular base pipe 38, a filtering media 40 outwardly overlying the base pipe, and a generally tubular protective outer shroud 42 outwardly overlying the filtering media. The shroud 42 has openings 44 formed through a sidewall thereof to admit fluid into the well screen 36. The fluid is filtered by passing inwardly through the filtering media 40. The fluid then flows inwardly through openings 46 formed through a sidewall of the base pipe 38.

[0055] The well screen 36 may be radially expanded

utilizing any of various methods. For example, a swage may be passed through the base pipe 38, fluid pressure may be applied to a membrane positioned within the base pipe, etc. Thus, any method of expanding the well screen 36 may be used, without departing from the principles of the present invention.

[0056] The shroud 42 protects the filtering media 40 from damage while the well screen 36 is being conveyed and positioned in a well. Additionally, if the well screen 36 is used in a method, such as the method 10 described above, wherein the well screen is expanded into radial contact with a wellbore, the shroud 42 also protects the filtering media 40 from damage due to such contact, and provides radial support to prevent collapse of the wellbore. Thus, the shroud 42 is preferably constructed of a durable, deformable, high strength material, such as steel, although other materials may be used in keeping with the principles of the present invention.

[0057] It will be readily appreciated that, when the base pipe 38 is expanded radially outward, the filtering media 40 will be radially compressed between the shroud 42 and the base pipe. Because of differential expansion between the base pipe 38 and the shroud 42, it may be difficult or otherwise undesirable to maintain alignment between the openings 44 in the shroud and the openings 46 in the base pipe. This lack of alignment between the openings 44, 46 and compression of the filtering media 40 between the shroud 42 and the base pipe 38 could severely restrict the flow of fluid into the well screen 36. However, the filtering media 40 includes features which completely or substantially eliminate this potential problem.

[0058] Specifically, the filtering media 40 includes three layers of filtering material – an outer relatively coarse layer 48, a middle relatively fine layer 50, and an inner relatively coarse layer 52. The terms "fine" and "coarse" are used herein to indicate the relative size of particles permitted to pass through the filter layers 48, 50, 52. That is, the middle layer 50 filters fine or small-sized particles from fluid passing therethrough, while the inner and outer layers 48, 52 filter coarse or larger-sized particles from fluid passing therethrough.

[0059] However, the inner and outer layers 48, 52 are not necessarily used for their filtering properties, although at least the outer layer 48 will filter larger-sized particles from fluid flowing into the well screen 36. Instead, they are used primarily to provide for flow between the openings 44, 46 after the base pipe 38 is expanded. For example, if the filter layers 48, 52 are made of a relatively coarse woven material as depicted in FIG. 2, fluid may flow transversely through the layers between the shroud 42 and the base pipe 38. Thus, fluid may flow into one of the openings 44, flow transversely through the outer filter layer 48, flow inwardly through the middle filter layer 50, flow transversely through the inner filter layer 52 to one of the openings 46, and then flow inwardly through the opening 46. Therefore, even if the filtering media 40 is radially compressed between

the shroud 42 and the base pipe 38, and the openings 44 are not aligned with the openings 46, fluid may still flow relatively unimpeded through the filtering media (other than the resistance to flow due to the relatively fine middle filter layer 50).

[0060] Another method of providing for transverse fluid flow between the shroud 42 and the base pipe 38 is to form grooves or recesses 55 internally on the shroud and/or grooves or recesses 57 externally on the base pipe. In this manner, either or both of the filter layers 48, 52 may be eliminated from the filtering media 40.

[0061] Preferably the filter layers 48, 50, 52 are each made of a woven metal material, with strands thereof sintered to each other and oriented helically relative to a longitudinal axis 54 of the base pipe 38. Sintering of the strands improves the strength of the filter layers 48, 50, 52 while maintaining consistency in the spacing between the strands when the layers are radially outwardly expanded. Orienting the strands helically relative to the base pipe axis 54 aids in preventing distortion of the filter layers 48, 50, 52 when the layers are radially outwardly expanded. However, it is to be clearly understood that it is not necessary in keeping with the principles of the present invention for the filtering media 40 to be made up of multiple layers 48, 50, 52 of woven material having sintered strands oriented helically relative to the base pipe axis 54, since other types of filtering media may be used in the well screen 36.

[0062] Note that the filtering media 40 may be stretched circumferentially when the well screen 36 is radially outwardly expanded. Preferably, this stretching of the filtering media 40 results in a change of less than fifty percent in the size of the openings for fluid flow through each of the layers 48, 50, 52. Additionally, it is preferred that the maximum size of the openings for fluid flow through the one of the layers 48, 50, 52 having the smallest mesh (i.e., the layer filtering the smallest particles from the fluid flowing therethrough) is 500 μm . Thus, after the well screen 36 is radially outwardly expanded, the filtering media 40 preferably filters particles having a size of greater than 500 μm from the fluid flowing therethrough.

[0063] Referring additionally now to FIGS. 3A & B, an elevational view of a portion of the base pipe 38 is representatively illustrated apart from the remainder of the well screen 36. The portion of the base pipe 38 illustrated in FIGS. 3A & B is shown as if the base pipe were "unrolled" or flattened from its normal tubular form. FIG. 3A shows the portion of the base pipe 38 prior to radial expansion of the base pipe, and FIG. 3B shows the portion of the base pipe after it has been radially expanded.

[0064] In FIG. 3A it may be seen that the openings 46 are arranged helically on the base pipe 38 relative to the longitudinal axis 54. This arrangement of the openings 46 provides good hoop strength in the base pipe 38 and provides support for the filtering media 40.

[0065] In FIG. 3B, it may be seen that the openings 46 are axially compressed when the base pipe 38 is ra-

dially extended. Some axial shortening of the base pipe 38 occurs when it is radially outwardly extended. The helical arrangement of the openings 46 relative to the base pipe longitudinal axis 54 may increase the axial shortening of the base pipe 38 while providing enhanced control over the final expanded size of the well screen 36.

[0066] Referring additionally now to FIGS. 4A & B, the portion of the base pipe 38 is again illustrated in "unrolled" form, with FIG. 4A showing the portion of the base pipe prior to radial expansion of the base pipe, and FIG. 4B showing the portion of the base pipe after the base pipe has been radially expanded. FIGS. 4A & B depict an alternate configuration of the base pipe 38 in which the openings 46 are replaced by multiple series of rows 56 of holes 58.

[0067] The series of rows 56 are arranged helically on the base pipe 38 relative to the longitudinal axis 54, with each row extending parallel to the longitudinal axis 54. The holes 58 of each row 56 are arranged along a straight line. However, it should be clear that this helical arrangement of the series of rows 56 relative to the axis 54, the parallel relationship between each row and the axis, and the linear arrangement of the holes 58 within each row may be changed, without departing from the principles of the present invention.

[0068] By substituting the smaller holes 58 for the openings 46, the torsional and tensile strength of the base pipe 38 is enhanced. When the base pipe 38 is expanded as depicted in FIG. 4B, the holes 58 of each row 56 interconnect with each other to form larger openings. Thus, a desired final flow area through the sidewall of the base pipe 38 may be achieved after the base pipe is radially expanded, even though the desired flow area is not present before the base pipe is expanded. The helical arrangement of the series of rows 56 may also increase the axial shortening of the base pipe 38 while providing enhanced control over the final expanded size of the well screen 36.

[0069] Referring additionally now to FIG. 5, another well screen 60 embodying principles of the present invention is representatively illustrated. The well screen 60 may be used in the method 10 described above, or it may be used in any other method, without departing from the principles of the present invention.

[0070] The well screen 60 includes a generally tubular base pipe 62 having a longitudinal axis 64, an elongated strip of filtering media 66 outwardly overlying the base pipe, and generally tubular transition members 68 used for attaching the filtering media to the base pipe. Although not shown in FIG. 5, the well screen 60 may also include a generally tubular outer shroud outwardly overlying the filtering media 66.

[0071] The filtering media 66 may be made of a similar material and may have similar layers of filtering material as the filtering media 40 described above. As depicted in FIG. 5, strands of the filtering material are oriented helically relative to the base pipe longitudinal axis 64.

The filtering media 66 is itself wrapped helically about the base pipe 62 in multiple wraps.

[0072] As with the filtering media 40 described above, the filtering media 66 is circumferentially stretched when the well screen 60 is radially expanded. Preferably, the openings for fluid flow through the filtering media 66 change in size less than fifty percent, and the filtering media filters particles having a size greater 500 µm from the fluid flowing through the filtering media, when the well screen 60 is radially expanded.

[0073] Referring additionally now to FIG. 6, an enlarged view of a portion of the well screen 60 (indicated by the encircled area designated by the reference number 6 in FIG. 5) is representatively illustrated. In this view a connection between adjacent wraps of the filtering media 66 may be seen. Specifically, the connection is a welded seam 70 between the filtering media 66 wraps. The seam 70 extends helically about the base pipe longitudinal axis 64.

[0074] Referring additionally now to FIG. 7, an alternate connection between adjacent wraps of the filtering media 66 may be seen. Instead of welding the filtering media 66 wraps to each other, a connector 72 is welded between adjacent wraps. The connector 72 extends helically about the base pipe longitudinal axis 64.

[0075] Note that the connector 72 spaces apart the adjacent filtering media 66 wraps. This spacing apart of the filtering media 66 wraps provides a convenient location for lines 74 extending from one end to the other on the well screen 60. The lines 74 may include one or more of a hydraulic line for delivering and/or returning fluid and/or fluid pressure downhole, a chemical injection line, an electric line for communicating data or transmitting power downhole, a communication line, such as a fiber optic cable, etc. Any other type of line may be used as one or more of the lines 74 in keeping with the principles of the present invention.

[0076] The lines 74 are depicted in FIG. 7 as being externally disposed relative to the connector 72, but it is to be understood that the lines may be otherwise positioned. For example, the lines 74 could be positioned beneath the connector 72, the lines could extend through a hollow connector, etc.

[0077] Referring additionally now to FIGS. 8A & B, another well screen 76 embodying principles of the present invention is representatively illustrated. In FIG. 8A, the well screen 76 is depicted as it is conveyed into a well. In FIG. 8B, the well screen 76 is depicted after a base pipe 78 thereof has been radially outwardly extended.

[0078] The well screen 76 includes the base pipe 78 with interconnected circumferentially alternating filtering portions 80 and expansion portions 82 outwardly overlying the base pipe. The filtering portions 80 each include an elongated strip of filtering media 84 and an elongated shroud strip 86 outwardly overlying the filtering media. The filtering media 84 may be similar to the filtering media 40 described above, or it may be another type of filtering media. The expansion portions 82 may

be made of a suitable deformable material and, as depicted in FIG. 8A, may include longitudinally extending corrugations 88 formed thereon to facilitate circumferential lengthening of the expansion portions.

5 [0079] In FIG. 8B it may be seen that the expansion portions 82 have been lengthened circumferentially relative to the base pipe 78 as the base pipe has been radially outwardly extended. This increase in the circumferential lengths of the expansion portions 82 has increased the circumferential separation between the filtering portions 80, thereby permitting radially outward displacement of the filtering portions, without requiring substantial stretching, lengthening, or other deformation of the filtering media 84, and thus preventing damage to the filtering media.

10 [0080] The expansion portions 82 may be otherwise configured, without departing from the principles of the present invention. For example, the expansion portions 82 may be made of a material which is readily stretched, without the need of forming corrugations, folds, etc. theron, the expansion portions may be otherwise lengthened, such as by using telescoping members, etc.

15 [0081] Furthermore, the expansion portions 82 may be physically connected to the filtering portions 80 in any manner, without departing from the principles of the present invention. For example, the expansion portions 82 may be attached directly to the filtering medias 84 and/or directly to the shrouds 86, or to another structure of the filtering portions, etc. It also is not necessary for only one of the expansion portions 82 to be interconnected between only two of the filtering portions 80.

20 [0082] Referring additionally now to FIGS. 9A & B, another well screen 90 embodying principles of the present invention is representatively illustrated. The well screen 90 is depicted in FIG. 9A in a radially compressed configuration in which it is conveyed in a well. The well screen 90 is depicted in FIG. 9B in a radially expanded configuration.

25 [0083] Note that the well screen 90 is similar in many respects to the well screen 76 described above, in that it includes a base pipe 92 with circumferentially alternating filtering portion strips 94 and expansion portion strips 96 outwardly overlying the base pipe. The filtering portions 94 include filtering media 98 and shroud 100 strips similar to those described above, and the expansion portions 96 have longitudinally extending corrugations 102 formed thereon.

30 [0084] However, in the radially compressed configuration of the well screen 90, the base pipe 92 has longitudinally extending corrugations or undulations 104 formed thereon which radially reduce the size of the base pipe. The undulations 104 give the base pipe 92 an hourglass-shaped cross-section as depicted in FIG. 9A. When the base pipe 92 is radially outwardly extended, the undulations 104 are substantially eliminated, as are the corrugations 102 of the expansion portions 96, and the filtering portions 94 are radially outwardly displaced.

[0085] Another difference between the well screens 76, 90 is that the well screen 90 includes retaining members 106 securing the expansion strips 96 in compressed configurations thereof, as depicted in FIG. 9A. When the base pipe 92 is radially outwardly extended, the retaining members 106 release, thereby permitting the expansion strips 96 to circumferentially lengthen relative to the base pipe, as depicted in FIG. 9B. In the compressed configuration of the well screen 90, each of the retaining members 106 may be attached between two of the shroud strips 100.

[0086] Referring additionally now to FIGS. 10A & B, another well screen 108 embodying principles of the present invention is representatively illustrated. The well screen 108 is depicted in a radially compressed configuration in FIG. 10A, in which the well screen is conveyed in a well. In FIG. 10B, the well screen 108 is depicted in a radially expanded configuration.

[0087] The well screen 108 is very similar to the well screen 90 described above, in that it includes a base pipe 120 and circumferentially alternating strips of expansion portions 110 and filtering portions 112. The filtering portions 112 each include a filtering media strip 114 and an external shroud strip 116. The filtering media 114 may be similar to the filtering media 40 described above. The expansion portions 110 are interconnected between the filtering portions 112. A retaining member 118 secures each expansion portion 110 in a compressed configuration until the base pipe 120 is radially outwardly expanded.

[0088] However, in the well screen 108, the base pipe 120 has longitudinally extending folds 122 formed thereon in the radially compressed configuration of the well screen. The expansion portions 110 also have longitudinally extending folds 124 formed thereon. When the base pipe 120 is radially expanded, the folds 122, 124 are partially or completely eliminated, as depicted in FIG. 10B.

[0089] Note also that the retaining members 118 are interconnected between opposite circumferential ends of each of the expansion portions 110 (see FIG. 10A), instead of being interconnected to the expansion portions 112. When the base pipe 120 is radially expanded, the retaining members 118 release and permit the expansion portions 110 to "unfold" or otherwise lengthen circumferentially.

[0090] Referring additionally now to FIG. 11, another well screen 126 embodying principles of the present invention is representatively illustrated. The well screen 126 includes a filtering media 128 outwardly overlying a generally tubular base pipe 130. The filtering media 128 is depicted as a generally tubular structure having circumferentially extending slots 132 formed therethrough, with the slots being helically arranged relative to a longitudinal axis 134 of the base pipe. Of course, the filtering media 128 may be otherwise constructed, without departing from the principles of the present invention.

[0091] The filtering media 128 is preferably made of a suitable durable and deformable material, such as steel, through which the slots 132 may be readily formed, such as by laser machining, water cutting, etc.

5 5 Alternatively, each of the slots 132 could instead be a row of closely spaced small diameter holes (for example, having a diameter of approximately 0.008 in [0.2 mm] and spaced approximately 0.016 in [0.41 mm] apart). The slots or holes 132 are used to filter fluid flowing inwardly through the filtering media 128.

[0092] The filtering media 128 has corrugations or pleats 136 formed thereon. The pleats 136 may be seen in FIG. 12, which is a cross-sectional view of the well screen 126, taken along line 12-12 of FIG. 11. The pleats 136 permit the filtering media 128 to lengthen circumferentially when the base pipe 130 is expanded radially outward, without substantially stretching the filtering media material.

10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 10000 10005 10010 10015 10020 10025 10030 10035 10040 10045 10050 10055 10060 10065 10070 10075 10080 10085 10090 10095 10100 10105 10110 10115 10120 10125 10130 10135 10140 10145 10150 1

media (see outer layer 48 in FIG. 2) may not be used. Additionally, pleats or corrugations 146 are formed on an elongated expansion portion 152 interconnected between circumferential ends of the filtering media 144. [0097] When the base pipe 142 is radially expanded, the corrugations 146 are fully or at least partially extended, thereby circumferentially lengthening the expansion portion 152 and permitting the filtering media 144 to be radially outwardly displaced without requiring substantial stretching of the filtering material.

[0098] Representatively illustrated in FIG. 14 is another well screen 154 embodying principles of the present invention. The well screen 154 is very similar to the well screen 140 described above, in that it includes a generally tubular base pipe 156, a filtering media 158 outwardly overlying the base pipe, an outer protective shroud 160 and ribs 162 extending longitudinally between the shroud and the filtering media. The filtering media 158 may be similar to the filtering media 40 described above, with the exception that it may not include the outer relatively coarse layer of filtering material 48, since the ribs 162 should provide for transverse flow of fluid between the shroud 160 and the filtering media.

[0099] However, instead of the expansion portion 152 of the well screen 140, the well screen 154 differs in that its filtering media 158 has longitudinally extending corrugations 164 formed directly thereon. When the base pipe 156 is radially expanded, the corrugations 164 are fully or at least partially straightened, thereby circumferentially lengthening the filtering media 158 and permitting it to be radially outwardly displaced without substantially stretching the filtering material.

[0100] Referring additionally now to FIGS. 15-17, another well screen 166 embodying principles of the present invention is representatively illustrated. The well screen 166 is shown in an elevational view in FIG. 15, in a cross-sectional view in FIG. 16 taken along longitudinal line 16-16 of FIG. 15, and in an enlarged cross-sectional view in FIG. 17 taken along lateral line 17-17 of FIG. 15.

[0101] The well screen 166 is similar in some respects to the well screen 126 described above, in that it includes a generally tubular base pipe 168, a generally tubular and laterally slotted filtering media 170 outwardly overlying the base pipe, and a series of circumferentially spaced apart longitudinally extending ribs 172 disposed between the filtering media and the base pipe. Slots 174 in the filtering media 170 extend laterally, are arranged in series extending helically about the base pipe 168, are used to filter fluid flowing therethrough, and may be replaced by rows of relatively small diameter closely spaced holes as described above for the slots 132.

[0102] However, the well screen 166 differs in some respects from the previously described well screen 126 in that one or more of the ribs 172 may be hollow and may have lines extending therethrough, and the filtering media 170 does not include the pleats 136. An enlarged

scale cross-sectional view of one of the ribs 172 is shown in FIG. 18, wherein it may be seen that a hydraulic or chemical injection line 176, an electrical line 178 and a fiber optic line 180 extend through the hollow rib. These lines may be used to power equipment in a well below the well screen 166, communicate with tools in the well, etc., and it is to be clearly understood that any type of line may be used without departing from the principles of the present invention.

[0103] Another useful purpose for the hollow ribs 172 is to prevent excessive expansion force from being imparted to the filtering media 170. For example, when the base pipe 168 is radially outwardly expanded, the expansion force used to expand the base pipe is transmitted via the ribs 172 to the filtering media 170. The ribs 172 are compressed between the base pipe 168 and the filtering media 170 by the expansion force and, if the expansion force is excessive, the ribs will collapse, thereby preventing the excessive force from being transmitted to the filtering media. This collapse of the ribs 172 may be useful in preventing damage to the filtering media 170 so that the well screen 166 may still be used, even though an excessive expansion force has been applied to the base pipe 168.

[0104] Note that the slots 174 will decrease in width when the base pipe 168 is radially expanded. This is due to the fact that the filtering media 170 is axially shortened somewhat when it is radially expanded, due to the filtering media being stretched circumferentially. Preferably, the filtering media 170 filters particles greater than 500 µm from the fluid flowing therethrough (i.e., the slots 174 have a width of less than or equal to 500 µm) when the well screen 166 is radially expanded. In addition, it is preferred that the width of the slots 174 decrease less than fifty percent when the well screen 166 is radially expanded.

[0105] Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the invention, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to these specific embodiments, and such changes are contemplated by the principles of the present invention. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present invention being limited solely by the appended claims.

50 Claims

1. An expandable well screen, comprising: a filtering media, the filtering media stretching circumferentially when the well screen is radially outwardly expanded.
2. A well screen according to Claim 1, wherein the filtering media comprises an elongated strip disposed

in a helical configuration.

3. An expandable well screen, comprising: a generally tubular base pipe having a longitudinal axis and a series of spaced apart rows of holes formed through a sidewall of the base pipe, the holes of each row interconnecting with each other when the base pipe is expanded radially outward; and a filtering media configured for filtering fluid flowing through the base pipe holes. 5
4. An expandable well screen according to Claim 3, wherein the series of rows of holes is arranged helically on the base pipe relative to the longitudinal axis. 10
5. An expandable well screen, comprising: a generally tubular base pipe having a longitudinal axis and a series of holes formed through a sidewall of the base pipe, the holes being distributed helically relative to the base pipe longitudinal axis, and each of the holes being compressed in a direction of the base pipe longitudinal axis when the base pipe is expanded radially outward; and a filtering media disposed externally on the base pipe. 15
6. An expandable well screen according to Claim 5, further comprising a generally tubular protective shroud outwardly overlying the filtering media. 20
7. An expandable well screen, comprising: an elongated strip of filtering media wrapped helically about a longitudinal axis. 25
8. An expandable well screen, comprising: multiple elongated strips of filtering media spaced apart and distributed circumferentially about a longitudinal axis and extending parallel to the longitudinal axis; and multiple elongated expansion strips, one of the expansion strips being interconnected between each adjacent pair of the filtering media strips, and the expansion strips lengthening circumferentially to thereby increase circumferential separation between the filtering media strips. 30
9. An expandable well screen, comprising: a generally tubular filtering media, the filtering media including expansion portions thereof permitting circumferential lengthening of the filtering media. 35
10. An expandable well screen, comprising: a filtering media; a series of longitudinally extending and circumferentially distributed ribs disposed externally relative to the filtering media; and a generally tubular protective shroud outwardly overlying the ribs. 40

50

55

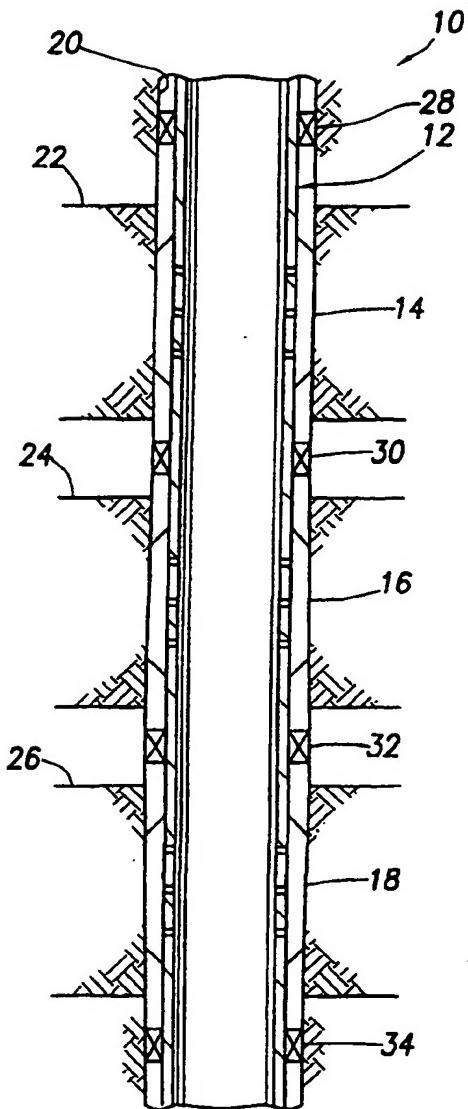
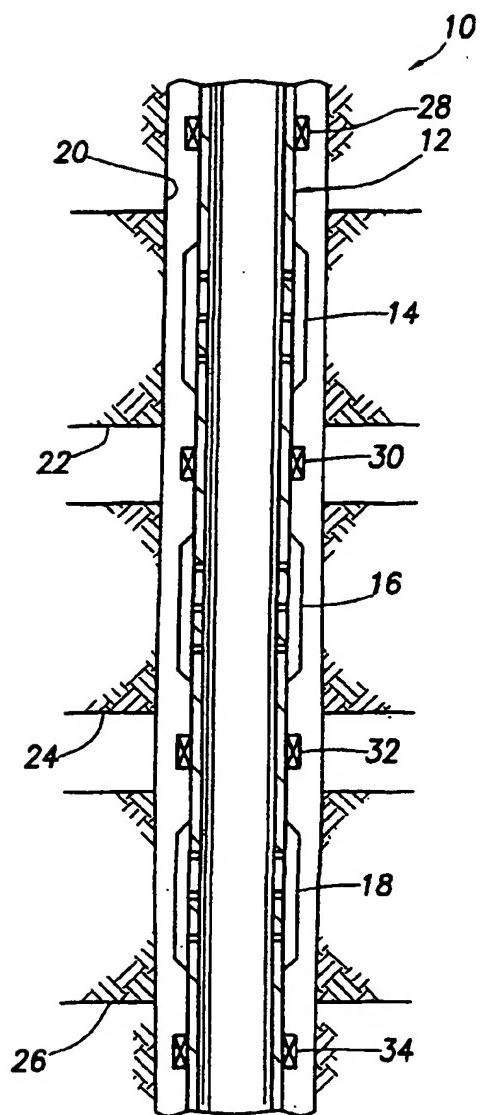


FIG. 1A

FIG. 1B

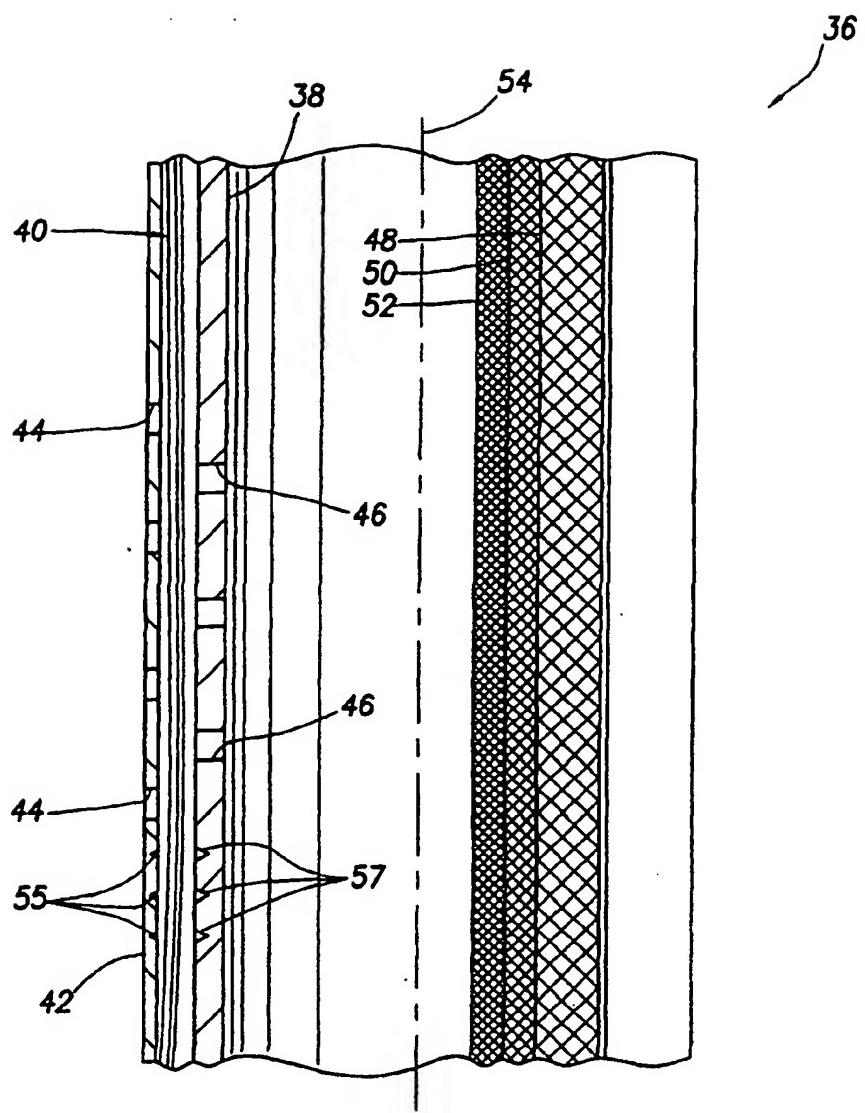


FIG.2

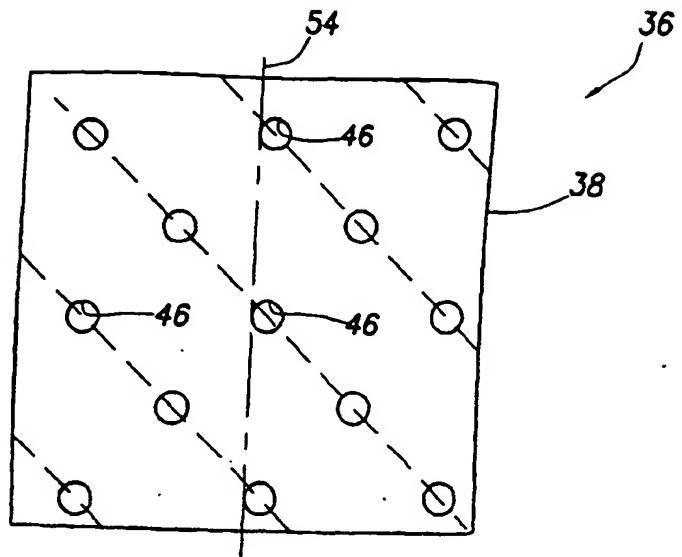


FIG. 3A

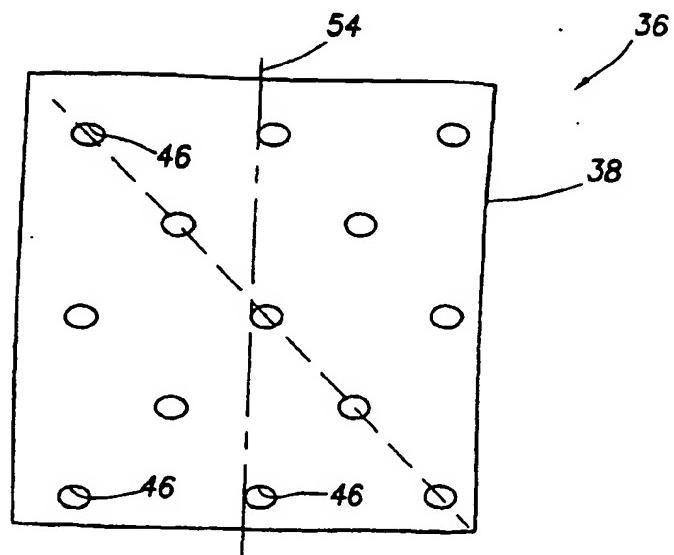


FIG. 3B

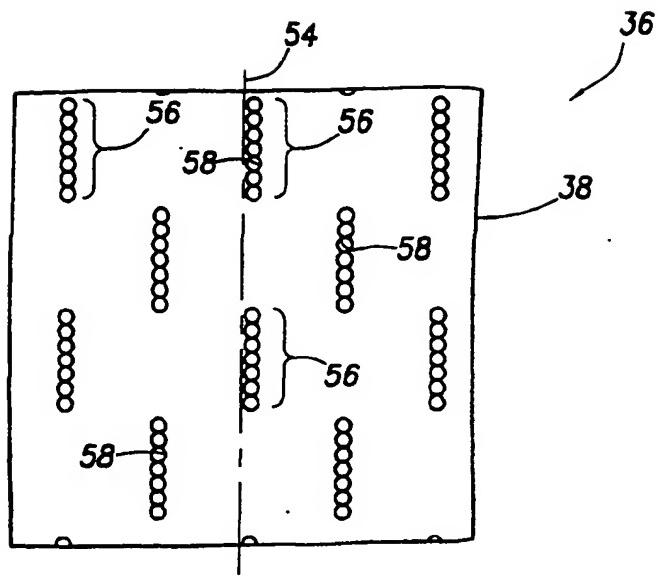


FIG.4A

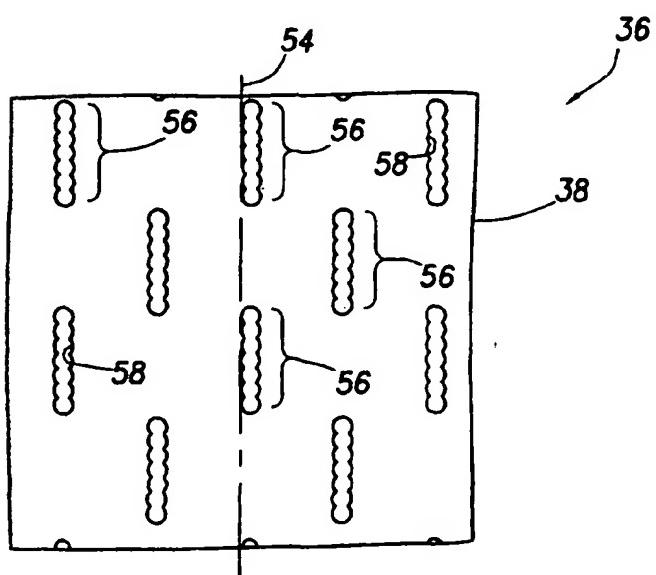


FIG.4B

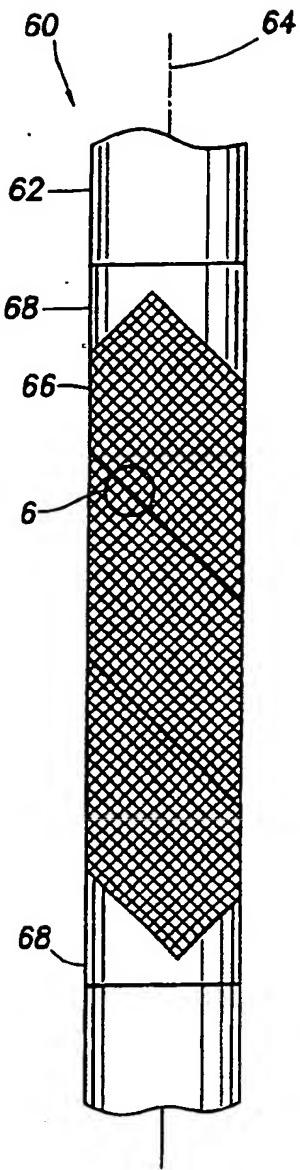


FIG.5

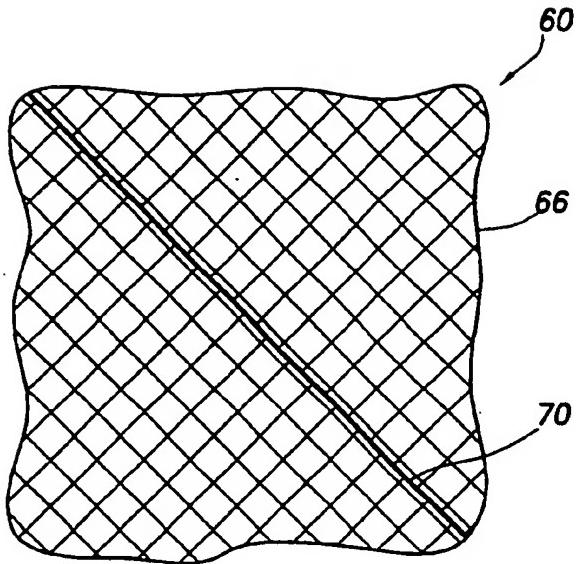


FIG.6

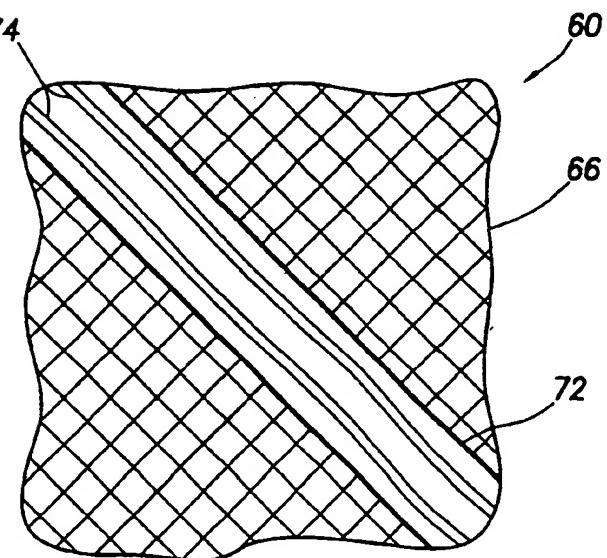


FIG.7

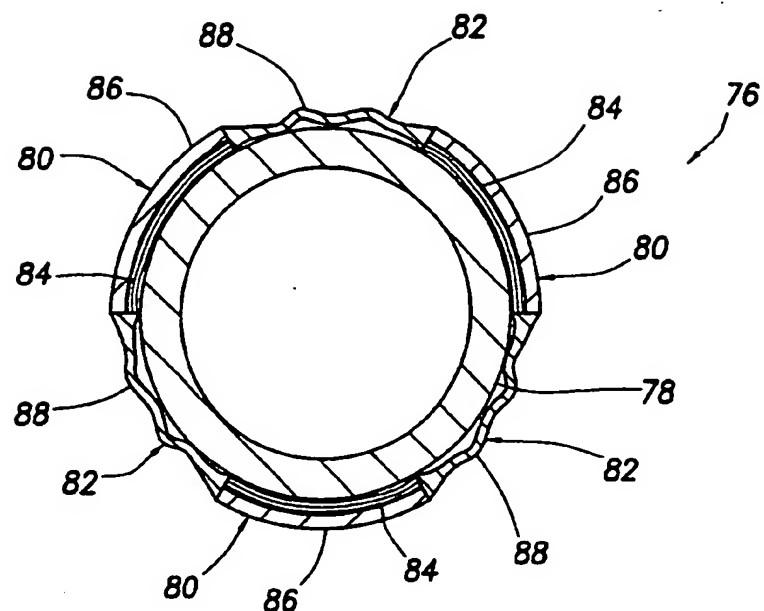


FIG.8A

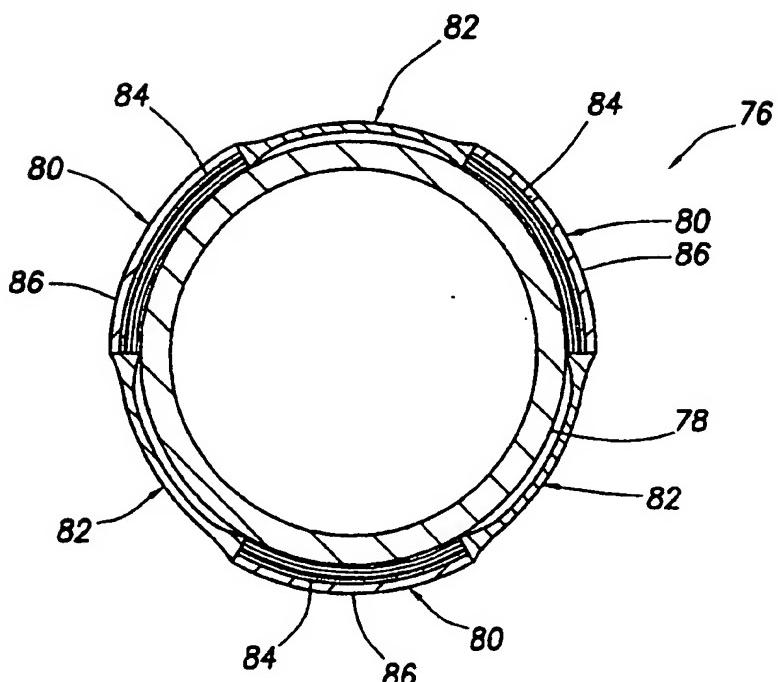


FIG.8B

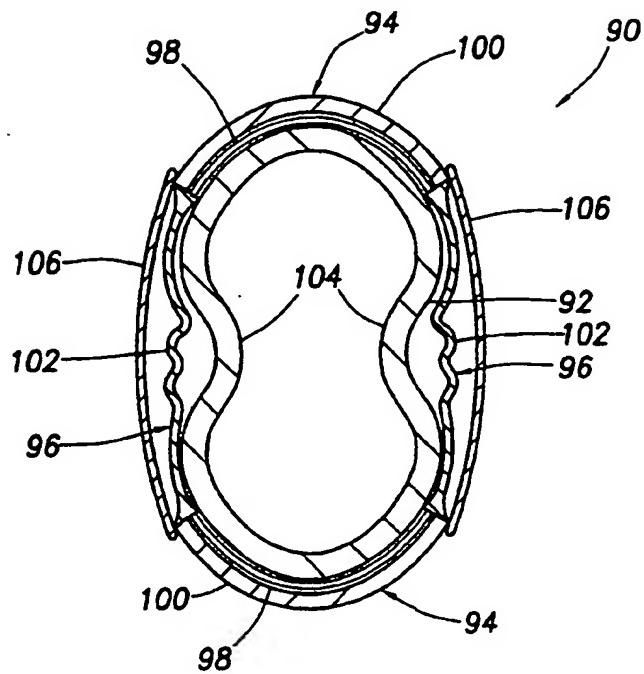


FIG.9A

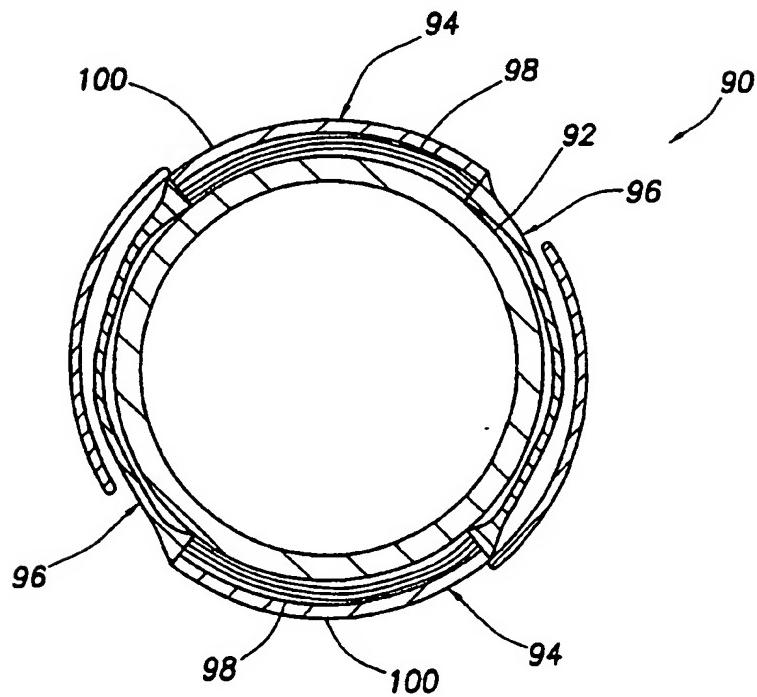


FIG.9B

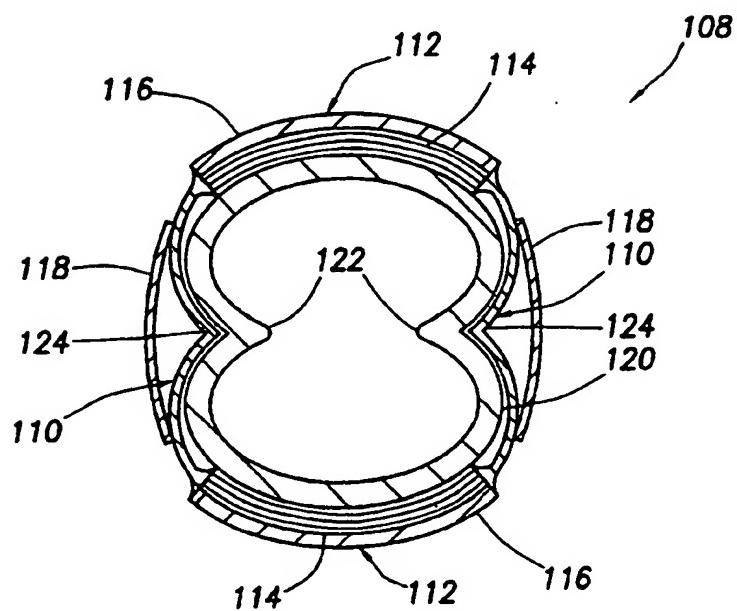


FIG. 10A

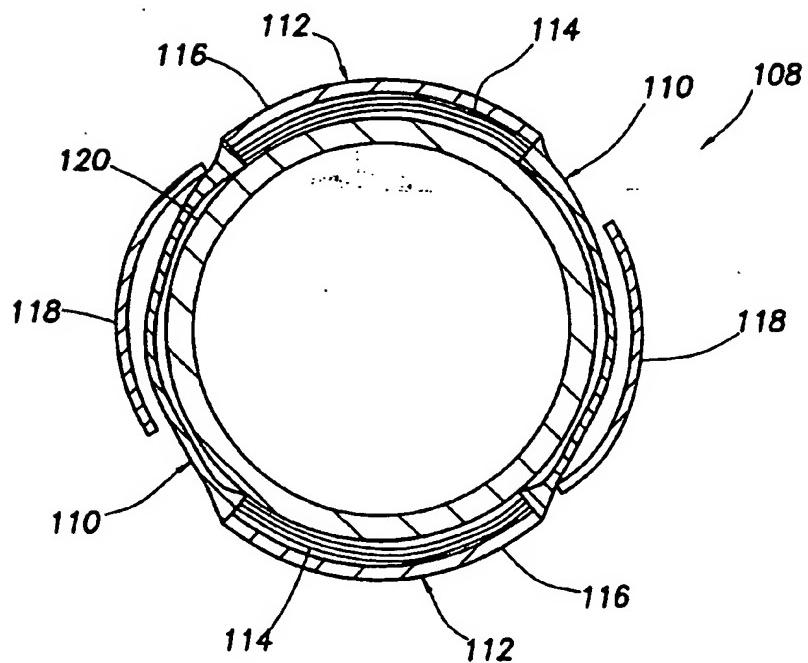


FIG. 10B

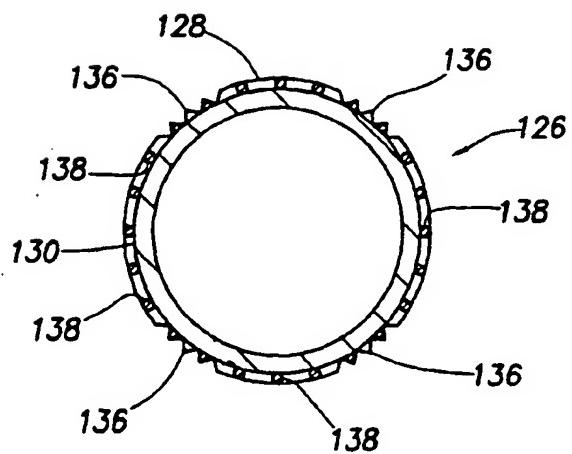
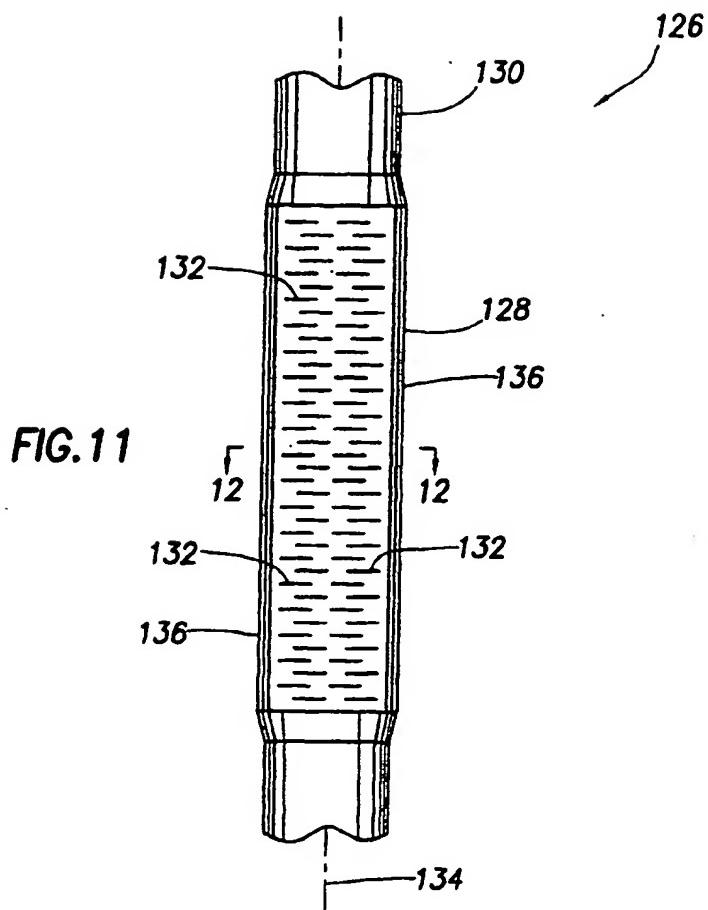


FIG.12

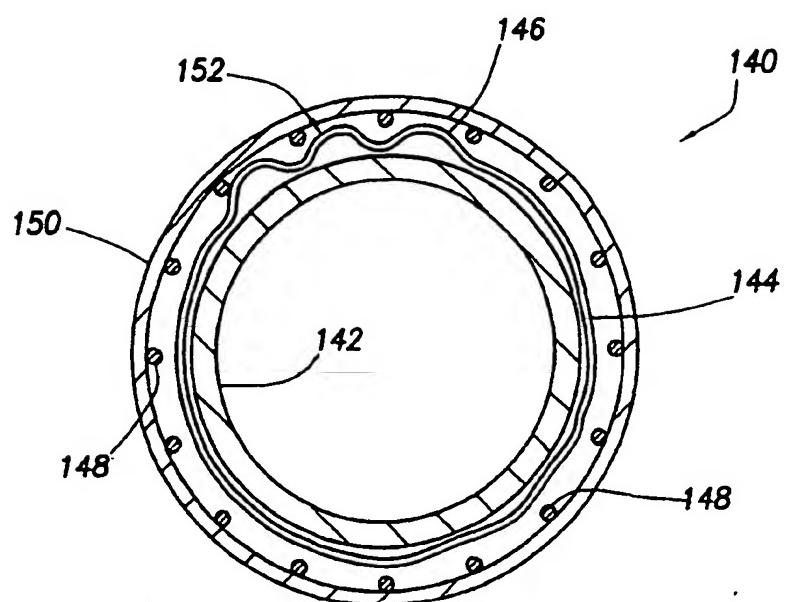


FIG.13

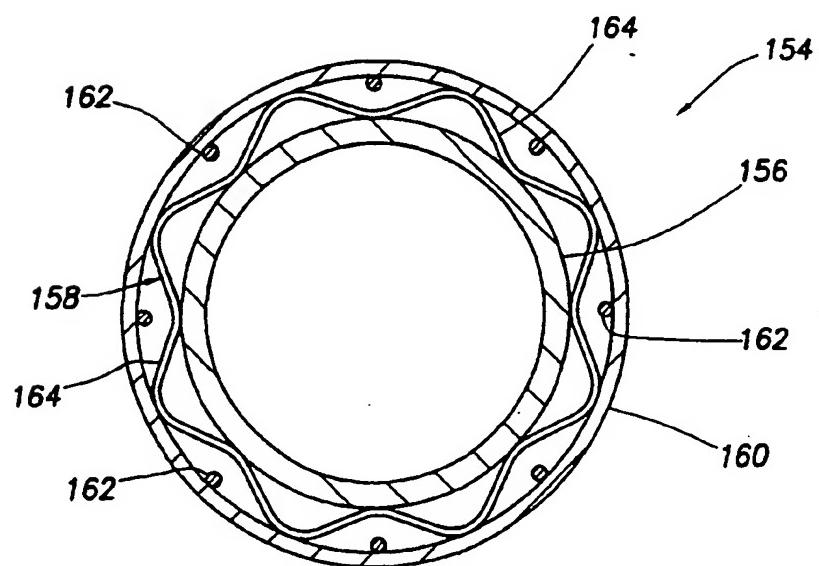


FIG.14

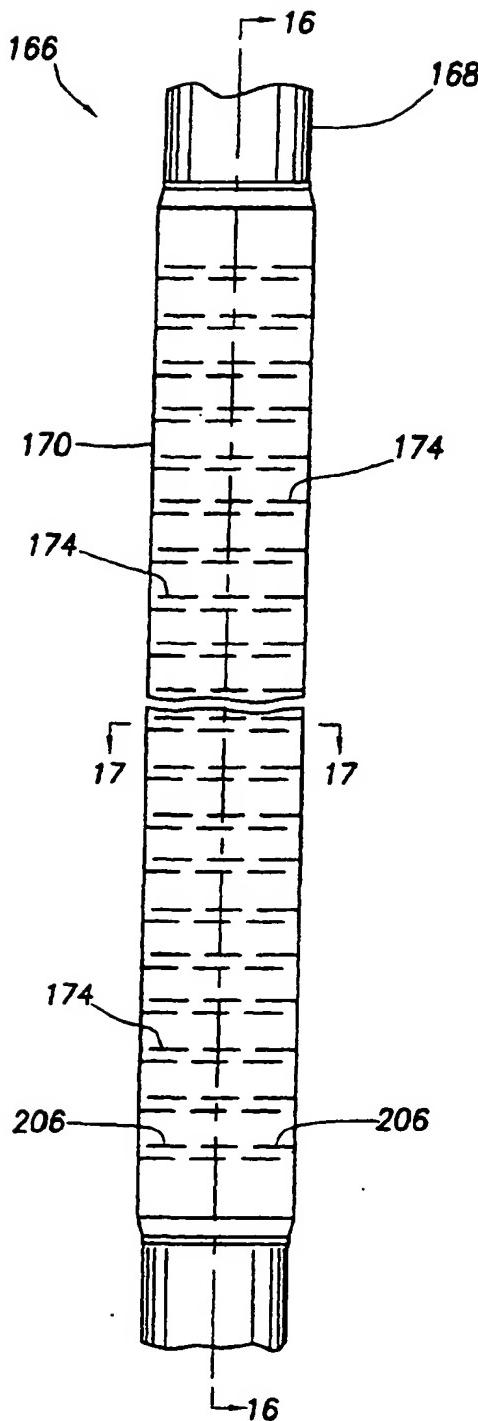


FIG. 15

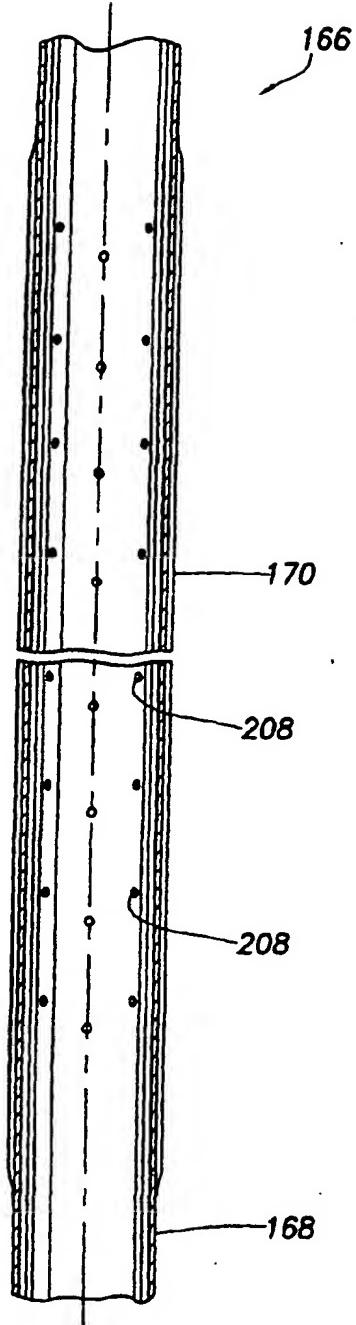


FIG. 16

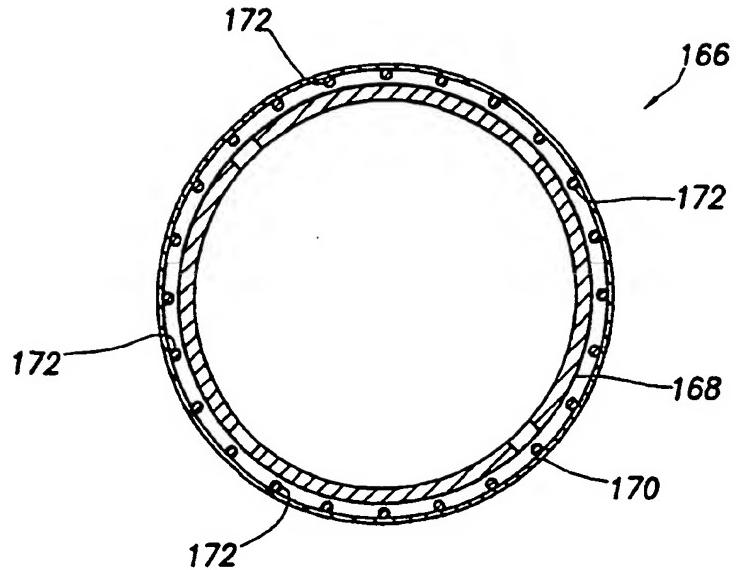


FIG.17

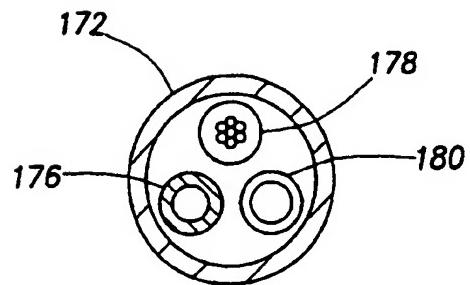


FIG.18

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 152 120 A3

(12)

EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
12.06.2002 Bulletin 2002/24

(51) Int Cl. 7: E21B 43/10, E21B 43/08

(43) Date of publication A2:
07.11.2001 Bulletin 2001/45

(21) Application number: 01304042.3

(22) Date of filing: 03.05.2001

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 05.05.2000 US 565899

(71) Applicant: Halliburton Energy Services, Inc.
Dallas, Texas 75381-9052 (US)

(72) Inventors:
• Castano-Mears, Ana M.
Coppell, Texas 75019 (US)
• Gano, John C.
Carrollton, Texas 75007 (US)
• Echols, Ralph H.
Carrollton, Texas 75287 (US)

(74) Representative: Curtis, Philip Anthony et al
A.A. Thornton & Co.,
235 High Holborn
London WC1V 7LE (GB)

(54) Expandable well screen

(57) An expandable well screen (36) provides increased collapse, torsional and tensile strength. In an embodiment, the expandable well screen (36) includes a generally tubular base pipe (38) and an external filtering media (40). The well screen (36) is configured to have sufficient torsional and tensile strength for conveyance and positioning in a wellbore, while also having sufficient strength to prevent collapse when the screen (38) is radially expanded.

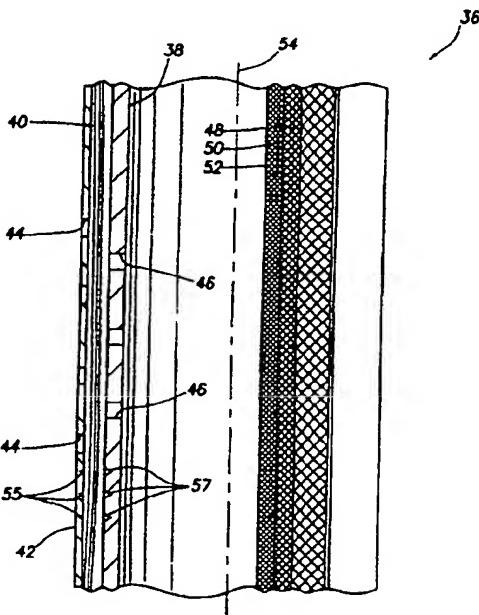


FIG.2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4042

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Description of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.)		
X	FR 2 771 133 A (DRILLFLEX) 21 May 1999 (1999-05-21) * claim 1 * * figures 6,7 *	1,9	E21B43/10 E21B43/08		
X	US 3 099 318 A (MILLER MONTGOMERY K ET AL) 30 July 1963 (1963-07-30) * column 7, line 29-32 * * figures 1-4 *	1,9			
X	WO 98 49423 A (SHELL CANADA LTD ;SHELL INT RESEARCH (NL)) 5 November 1998 (1998-11-05) * page 4, line 28-35 * * figures 3,4 *	7			
A	US 5 901 789 A (KENTER CORNELIS JAN ET AL) 11 May 1999 (1999-05-11) * the whole document *	1,3,5, 7-10			
<table border="1"> <tr> <td>TECHNICAL FIELDS SEARCHED (Int.Cl.)</td> </tr> <tr> <td>E21B</td> </tr> </table>				TECHNICAL FIELDS SEARCHED (Int.Cl.)	E21B
TECHNICAL FIELDS SEARCHED (Int.Cl.)					
E21B					
<p>The present search report has been drawn up for all claims</p>					
Place of search	Date or completion of the search	Examiner			
THE HAGUE	19 April 2002	Schouten, A			
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : technological background O : non-written disclosure P : intermediate document R : member of the same patent family, corresponding document			
<small>EPO FORM 1603.C02 (P04C01)</small>					

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 30 4042

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EPO file on. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-04-2002

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
FR 2771133	A	21-05-1999	FR AU WO	2771133 A1 1159199 A 9925951 A1	21-05-1999 07-06-1999 27-05-1999
US 3099318	A	30-07-1963	NONE		
WO 9849423	A	05-11-1998	AU AU BR WO EP NO	717503 B2 7651798 A 9809005 A 9849423 A1 0980462 A1 995248 A	30-03-2000 24-11-1998 08-08-2000 05-11-1998 23-02-2000 27-10-1999
US 5901789	A	11-05-1999	AU AU BR DE EA WO EP JP NO NZ US	710745 B2 7568096 A 9611456 A 69617258 D1 980433 A1 9717524 A2 0859902 A2 11514712 T 982087 A 322015 A 6012522 A	30-09-1999 29-05-1997 17-02-1999 03-01-2002 29-10-1998 15-05-1997 26-08-1998 14-12-1999 07-07-1998 28-10-1999 11-01-2000

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.